"The Economics of Mobile Money: harnessing the transformative power of technology to benefit the global poor."

Janine Aron and John Muellbauer

May 2019

Executive Summary

The aims of the paper

This paper introduces the novel phenomenon of mobile money, its regulation and its important role globally in the financial inclusion of the poor and unbanked. It examines possible channels for the economic influence of mobile money and evaluates new empirical evidence on the impact of mobile money.

The paper emphasises the *interconnectedness* of the many facets of mobile money: enabling regulation for mobile money operations; profitable, innovative and sustainable mobile money networks; greater international and regional network connectedness and the transfer of technology; financial inclusion and the improved financial literacy for the poorest, including the neglected participants, women and rural dwellers; promotion of trust in evolving and more efficient business networks; better functioning e-Government with less "leakage"; well-directed donor support and effective academic research. There are also important externalities including the reduction of corruption and the fostering of the "formalisation" of economies, and improved health and climate outcomes.

This paper offers conclusions, wide-ranging lessons and policy recommendations. If these are disseminated and coordination is managed judiciously, this could lead to a virtuous circle for the many participants and players.

What is mobile money?

The rapid growth since 2007 of Kenya's M-Pesa system ("M" is for mobile, and "pesa" is Swahili for money) through Safaricom, a subsidiary of Vodafone, has brought mobile money to international prominence. The spread of mobile money is a *global* phenomenon. By 2017, there were 276 mobile money services for the unbanked in 92 countries with more than 174 million (90-day) active registered accounts and over 44 million unregistered over-the-counter users (GSMA, 2017), see Figures 1 and 2. Mobile money is now available in two thirds of low- and middle-income countries. Vodafone alone exported the M-Pesa system to Afghanistan (2008), to India (2013), to Europe (Romania[1] in 2014 and Albania in 2015), and to many countries in Africa.

Mobile money refers to financial transaction services potentially available to anyone owning a mobile phone, including the unbanked global poor who are not a profitable target for commercial banks. An individual installs a mobile phone application on a SIM card, sets up an electronic money account with the mobile money services provider (usually a mobile network operator (MNO) acting alone or in

[1] In Romania, over a third of the population had no access to conventional banking, and seven million people mainly used cash, see *Africa's digital money heads to Europe* (Financial Times, 30th March 2014).

formal partnership with one or more banks, depending on the jurisdiction in the particular country), and deposits cash in exchange for electronic money.[2] The electronic money can be stored, withdrawn as cash, or transferred via a coded secure text message to others, without the customer or the recipient having a *formal* bank account. Crucially, even tiny amounts can be stored and securely transferred.

There is a distinction between mobile payments in economies like the US with deep financial markets, and mobile money payments in largely cash-based developing or emerging countries. In the former, payments are predominantly linked with *pre-existing* bank accounts (e.g. Apple Pay).[3] In the latter, most users are unbanked. As mobile money systems evolve, and smart-phones become affordable in poorer countries[4], their range of services could expand to link with products managed by formal financial institutions, such as banks and insurance companies. At the margins, this will *blur* the distinctions between mobile banking and mobile money. But the poorest customers will remain unbanked and rely on mobile money for basic financial services.

Even in advanced countries, the proportion of the under-banked and unbanked can be significant,[5] with the unbanked deterred from opening bank accounts by minimum balance requirements and fees. Recent moves to attract the US unbanked via mobile technology mirror the financial inclusion processes with mobile money in developing countries.[6] Security concerns about mobile payments have diminished in the US according to survey evidence (Federal Reserve, 2016). There may be a technological spill-over to less advanced economies from efforts to enhance security, including the use of biometrics. This could catalyse a transformation to a virtually cashless[7] economy, and a new role for some banks beyond traditional payments.

1. Introduction

Mobile money is *novel*: it was barely heard of a decade ago. Yet it has transformed the landscape of financial inclusion, spreading rapidly in developing and emerging market countries and "leapfrogging" the provision of formal banking services.[8] The poor are especially vulnerable to risk (e.g. from illness, unemployment, death of family members, or natural disasters). Enhancing financial inclusion of the unbanked urban and rural poor, a goal of the G20 group of countries, can help to diversify risk. Financial inclusion policy has previously focussed on extending access to *formal* banking services, but progress has been thwarted by cost and market failure challenges, Figure 3.

The new technology helps overcome the problems from weak institutional infrastructure and the cost structure of conventional banking. The poor mostly cannot afford the minimum balance requirements and regular charges of typical bank accounts. Mobile phone technology has the advantage that consumers themselves invest in a mobile phone handset, while the (scalable) infrastructure is already in place for the widespread distribution of airtime through secure network channels, Figure 4.

[2] Money is deposited into the account by giving cash to an agent, in return for electronic money via the mobile phone. To withdraw money, electronic money is transferred via the mobile phone to the agent's electronic money account and cash is received in return. Depositors do not receive interest on their electronic accounts and bear the risk of loss of value through inflation.

[3] In China, 80 percent of Chinese have at least one bank account (Global Findex data for 2017), and mobile payments providers like Alipay and WeChat Pay have leveraged the existing banking infrastructure.

[4] Smartphones below US$100 from Asian manufacturers are now commonplace and recycled smartphone markets are burgeoning (GSMA, 2017).

[5] Unbanked consumers comprise 9 percent (over 25 million adults) and under-banked consumers, 22 percent, of all US consumers (Federal Reserve, 2016); the under-banked possess, but do not use, a bank account.

[6] *US tries to boost access to 25m 'unbanked'* (Financial Times, 30th November 2015).

[7] On the merits of a cashless economy, including fighting corruption and money-laundering, see Rogoff (2016).

[8] This Policy Paper draws on Aron (2017) and Aron (2018).

By adopting mobile money, under-served citizens gain a secure means of transfer and payment at a lower cost, and safe and private storage of funds.

The technological innovation also helps to ameliorate the asymmetric information constraint faced by conventional banks in lending to the collateral-less poor. The movement of cash into electronic accounts gives a record, for the first time for the unbanked, of the history of their financial transactions in real time. By using algorithms[9], these records can provide evolving individual credit scores for the unbanked. After a designated period of usage and once a score is available, registered users of mobile money may obtain a pathway to *formal* banking services accessed only through a mobile phone: to interest-bearing savings accounts that can protect assets; to credit extension to invest in livelihoods; and insurance products that reduce risk.

The impact of enhancing *transparency* through electronic records is far-reaching. Tax collection could be improved by more visible spending, and more easily collected via mobile money payments. The transparency of records protects customers' rights and fosters trust in business, promoting the growth of efficient payments networks. Mobile money reduces high cost of international remittances while making them more readily traceable. Thus, mature mobile money systems and the records they produce help foster the "formalisation" of the economy, integrating informal sector users into business networks, formal banking and insurance, and linking them to government through social security, tax, and secure wages payments.

With the novelty and the rapid growth of mobile money systems, the parallel regulatory response has been caught off-balance. Regulation potentially straddles several branches of the existing law for business, telecommunications and prudential protection. Some countries responded with stringent protective restrictions in the early stages, stultifying growth and innovation, and creating barriers to entry (e.g. India). Others, notably Kenya, initially adopted a light-touch regulation and then adapted and tightened regulation over time as markets grew. Rather than each country "reinventing the wheel", the winning regulatory lessons should be shared and reinforced.

Demonstrating welfare and risk-sharing gains from mobile money across countries could bolster the case for significant government and donor support, and investment. A burgeoning body of micro-economic empirical literature has attempted to quantify the possible economic gains of access to secure financial services through mobile money (e.g. improved risk-sharing, food security, consumption, business profitability, saving and use of cash transfers), and factors driving the adoption of mobile money. However, this literature is burdened by a range of sometimes serious problems with data, methodology, and identification. Research on mobile money faces "selection" problems, since both the "roll-out" of mobile money by MNOs and their agents, and the adoption or usage of mobile money by individuals, may be influenced by other factors such as education, wealth, and changes in technology preference. There is mixed success using various methods and data sets in dealing with the resultant ambiguous causality. In practice it may be difficult to generalise from these models because the analysis is often highly contextual, and moreover economies evolve e.g. through technological change.

Moreover, such static micro-data-based snapshots are liable to understate the *system-wide* benefits of mobile money. The micro-analysis misses the positive externalities linked to network growth and from increased transparency and formalization of the economy.[10] The static analysis misses the likelihood that many benefits take time to be accumulate even at the individual level, so that the long-term benefit from mobile money is likely to be greater.

[9] Indeed, the FICO scores in the US, decisive in 90 percent of US lending decisions by 2015, are created in a similar manner, see *Big data: Credit where credit's due* (Financial Times, 4th February 2015).

[10] Every new user adds to the potential usefulness of the network for existing users, and lowers the average cost per user, given the fixed cost nature of the technology.

2. "Nuts and bolts" and the evolution of mobile money systems

Mobile money is a form of electronic money allowing the conduct of transactions through a mobile phone (Box 1). Mobile money systems rely on a large network of agents rather than bank branches. These agents are linked under various contractual arrangements with the mobile money operator. Establishing an agency network and training agents is a considerable early investment by operators to develop the market.[11] The typical authorized agents[12] of the mobile money services provider are shops or outlets staffed by small business owners. In Kenya, the mobile money system, M-Pesa, distinguishes between wholesalers and retail agents. Retail agents transact with their own cash and electronic money in their own M-Pesa accounts to meet customer demand. Wholesalers (banks or non-bank merchants) enjoy higher limits on electronic money stored in their M-Pesa accounts and perform a cash management service to allow retailers to maintain a liquid float.

Mobile money systems are often characterised by considerable innovation – new products and types of transactions have evolved, some in cooperation with financial institutions. With the wider availability of the smartphone, the possibilities will multiply, especially to enhance accessibility and the financial education of the unbanked through innovative graphic-based applications.

In poorer, cash-based countries, mobile money has been predominantly used for *private domestic transfers*[13]. Once a mobile phone user has a SIM card containing the mobile money application for their phone and has registered with a retail agent using their phone number and an identity document[14], cash deposits into their electronic mobile money account may be securely transferred electronically.[15] The user transfers money straightforwardly by accessing the service provider via an access code dialled from a mobile phone, entering the mobile phone number of the recipient and the amount to transfer, and authorising via a PIN code. A secure text message (SMS) with a code is sent in real time to the recipient, authorising a retail agent to transfer money from the remitter's account into cash for the designated recipient. Users pay the cost of transferring and withdrawing money, but there is no charge for depositing money.[16]

As mobile money systems have matured, they have evolved into a *broader payments platform*, see Figure 5, including the rapid expansion of *business usage* and *international remittances*. Payments include utility bills, rent, taxes, school fees, transport costs and retail payments. Business usage has expanded rapidly[17] through special networks for the payment of suppliers, bulk disbursements such as

[11] M-Pesa agents are compensated from transaction fees charged to customers. By 2017, there were over 136,000 M-Pesa agents countrywide (2017 Safaricom *Annual Report*), compared with about 2.73 commercial bank branches per 1000km^2 in 2017 (from IMF data, and thus totaling about 1590 branches).

[12] Third party merchants are not "agents" in a strict legal sense of having the legal authority to act for the service provider – this depends on the local regulation requirements.

[13] Jack and Suri (2014) observe that in Kenya, where families and social networks are widely-dispersed from internal migration, remittances on average travel 200km. Before mobile money, private domestic transfers used scarce post office branches or insecure intermediaries such as friends or bus-drivers.

[14] National regulators prescribe ID documents to comply with "know your customer" (KYC) regulations. This may pose challenges for the poor, especially where there is no national ID or voter's card.

[15] Electronic money can be sent from a customer's account to another account holder, but also to those who are not account holders. The latter transaction is more expensive, and the remitter's own account is debited.

[16] The graduated withdrawal fee for M-Pesa ranges from 0.44 percent for large sums to 20 percent for the smallest, and for transfers to other users, from 0.15 percent for the largest to 11 percent for the smallest (transfers smaller than Ksh 100 are free). The maximum allowed account balance is Ksh100,000 (US$987, in November 2018), the maximum daily transaction is Ksh140,000, the maximum and minimum per transaction are, respectively, Ksh70,000 and Ksh1 (US10cents): https://www.safaricom.co.ke/personal/m-pesa/getting-started/m-pesa-rates .

[17] For example, Safaricom in Kenya has pioneered the "Lipa na M-Pesa" ("pay by M-Pesa" in Swahili) business payments platform, an important growth area for the company, where business related payments (C2B, B2B, B2C)

promotional payments or salary payments, and potentially pensions.[18] This diversity has helped promote the hard-won profitability of mobile money systems, improve trust and efficiency in business, and guarantee consumer protection through a safe and recorded means of payment.

Donors and governments stand to gain from reduced disbursement costs, leakages and 'ghost recipients' by the secure payment of wages, social security, aid and other transfers. Government usage has lagged, though the cost savings especially in insecure environments could be significant.[19] The provision of basic services (e.g. from government-owned electricity and water companies) has the potential to enhance collection efficiency on a pay-as-you-use basis with mobile payments. Donors increasingly use mobile money for directed cash transfers, both conditional (CCT) and unconditional (UCT). This eliminates unreliable paper bureaucracy through instant and transparent digital records, reduces delays and makes cash transfers more cost effective for both the donor and recipient. Humanitarian aid is transforming from in-kind transfers, such as food or blankets, to cash assistance. In conflict situations, and for disaster relief, see Lucini and Sharma (2016), mobile technology can securely provide vital assistance to displaced populations through remote digital cash transfers, perceived as an often more rapid and effective method of providing help. For example, in Bidi Bidi, one of the world's largest refugee settlements in northern Uganda, a partnership between MNOs and NGOs has facilitated mobile money bulk payments for delivering humanitarian cash transfers (GSMA, 2017).

An important feature of mobile money is how it can facilitate access to different forms of *credit* through its records, monitoring and incentive-compatible contracts. For the poor in developing countries, even small amounts of credit are difficult to access from the banking sector. Credit information systems are undeveloped, and lenders seldom share information. Credit extension requires collateral or other guarantees to bridge the gap of asymmetric information between borrower and lender. Public and private credit bureaux are expensive to set up and run, and mostly cover a narrow range of firms and some wealthier individuals.[20]

New technology combined with mobile money provides a cheaper way of extending and monitoring credit and reducing asymmetries of information with *rudimentary credit scores*. Mobile money records reveal financial behaviour often for the first time for the unbanked. The dynamic credit scores are calculated from the stream of recorded financial actions by registered mobile money users over a period and the scores evolve monthly.[21] Credit scores may facilitate access to loan products from the formal banking sector accessed through the mobile device, enhancing financial inclusion.[22] The loans are largely short-term with a high interest rate, and progressively larger loans can be extended when a loan is successfully repaid.[23]

---

accounted for over a quarter of M-Pesa revenue in 2017 (Safaricom Financial results, https://www.safaricom.co.ke/investor-relation/financials/reports/financial-results).

[18] In August 2017, Safaricom announced it would open an application program interface (API) portal, for businesses to integrate their services with M-Pesa for a fast and simplified process.

[19] Iazzolino (2018) provides a recent review, though in a more general digital context than mobile money alone.

[20] For example, Sub-Saharan Africa scores 3.3 in a range of 0 to 8, for "Depth of Credit Information" (The World Bank's "Doing Business" website, May 2018) – and the score reflects only the existence and not the *effectiveness* of credit bureaux.

[21] The credit agency, Experian, uses proprietary algorithms to assess credit risk with as little as a month's history of anonymous and encrypted behavioural data from MNOs.

[22] In Kenya, the M-Shwari, launched in late 2012, are mobile money accounts linked with interest-bearing bank accounts accessed only through the mobile phone. A measure of the default rate on M-Shwari loans in 2016 was about 2 percent, measured by volume and value and on a comparable annualized basis, with an average loan size of Ksh4000 ($39) - *US groups tap tech to lend across east Africa* (Financial Times, 17th May 2016).

[23] M-Shwari loan sizes range from US$1to US$235 with a 30-day term but can be rolled over at a monthly fee of 7.5% (though this amounts to an interest rate at the high annual compounded rate of 138 percent).

A flexible form of credit for the purchase of durable goods, *hire-purchase credit*, has been made possible through mobile money systems for the first time for the unbanked, with secure remote payments for services and capital, tied to incentives. Private sector initiatives increasingly use such hire-purchase schemes for the provision of basic services. For example, affordable solar energy-powered electricity systems can be fully purchased via a pay-as-you-use basis, through mobile payments (Box 2).

Savings products via partner banks have been offered for some years; a fast-growing recent innovation is the extension of *pension products* and *investment products* (GSMA, 2017).[24]Another important spill-over effect that promotes inclusion to the formal financial sector is access to *micro-insurance products,* where regular remote payments can be taken securely via mobile payments. The poor seldom access traditional insurance products, owing to prohibitive delivery costs and limited awareness of such policies. Business models for micro-insurance have evolved using the mobile handset for mobile money users. Most popular is life insurance, including funeral expenses, covering three-quarters of offered products; the residual provide health insurance, accident coverage, or agricultural insurance (Pénicaud and Katakam, 2014).[25] The adverse selection problem is challenging, but delegation to trained third-parties in the field with expertise in insurance, and the appropriate pricing model with incentives, may facilitate take-up of these products.

A fast-growing product is *international remittances* through mobile money channels. Significant cross-border financial remittances are repatriated "home" or to refugees, by legal channels or by unlicensed, untracked and sometimes illegal means. Global trends for officially recorded remittance flows and costs are given in Table 1.[26] The *true* size of remittances, including unrecorded flows, is likely to be significantly larger. The potential gains from transparent and cheaper methods of remittance are significant. Lowering costs could attract more official remittances and re-channel "informal" remittances through official channels, improving the official statistics. The better economic management of remittances would be facilitated. A *proportionate approach* to risks from money laundering and the financing of terrorism was recommended by the Financial Action Task Force (FATF) in 2013 to address financial inclusion goals. Nevertheless, security concerns present a challenge because of poor compliance to international law at the *receiving* end. If the local compliance challenge can be overcome, mobile money (bound by "know your client" legislation and electronic recording of transactions) should facilitate remittances to war-torn countries with weak governance like Somalia, with limited or no functional banking.

3. Mobile money is essential to promote financial inclusion

The term "financial inclusion" is of recent vintage, and has gained currency with policymakers, most prominently in the Maya Declaration of 2011, when 80 regulatory institutions from 76 countries collectively endorsed a set of financial inclusion principles. The G20 has backed the Maya declaration, promoted indicators to measure "financial inclusion", and the G20 Summit in 2017 prominently endorsed digital approaches to financial inclusion. Mainstream definitions of financial inclusion share

[24] In some countries like Kenya and Ghana, treasury bills and government bonds can be bought using mobile money (GSMA, 2017), with mixed success.

[25] Just over 40 percent of providers charge a premium to customers automatically collected through mobile money; the remainder offer free mobile insurance for achieving stipulated airtime usage levels (the free basic cover can be boosted, and extra features added by paying a premium: the "freemium" business model) or are collected through airtime deductions. Insurance is increasingly used as a loyalty product. Claim disbursements are paid through mobile money or airtime accounts.

[26] The global average total cost for sending remittances in 2018Q1 was 7.1 percent, but the costs vary sharply by region, and across many African corridors remain well above 10 percent.

the goal of participation in the *formal* financial sector, which has severely constrained progress to inclusion. Until recently, use of *electronic* mobile money has *not* been counted as part of financial inclusion under most definitions. Mobile money's role has been viewed as a pathway for registered users to formal sector financial inclusion via products (insurance, credit and a bank savings account) accessed through a mobile phone.

Aron (2017) argues that a revised definition of financial inclusion should encompass *tiers* of semi-formal inclusion, and not focus on comprehensive formal banking sector inclusion. Mobile money has transformed the lives of poor consumers who can hold recorded cash privately in non-bank electronic accounts and perform financial transfers easily and cost effectively. Such users may not embrace the formal sector products even if they become available, for example, if they qualify for credit, the loans may be small and not adequate to purpose, creating a disincentive to participate. Moreover, the actual number of informal users may be far higher than is formally reported. South Asia has close to 90% of the global *unregistered* mobile money customers, using an over-the-counter (OTC) model where the challenges and costs of establishing identity in registering were circumvented in favour of a drive for early market share (Scharwatt et al. 2015).[27]

Fast-spreading and cheaper smartphones (and recycled smartphone handsets) potentially offer access to sophisticated features and a spectrum of financial services for huge numbers of illiterate people through well-designed applications (Villasenor 2013). Smartphone connections in Africa almost doubled over the two years to 2016 and are projected to double again from 2017 to 2020 (GSMA, 2017). To put these numbers in perspective, fewer than half of all Africans had mobile phone subscriptions in 2016, and only 30 percent of these were smartphones. However, application usage on a smartphone requires affordable access to the internet. The ITU[28] estimates that nearly three-quarters of Africans remain offline partly due to lack of a data signal and the high costs of downloading data (Figures 6 and 7). With less mobile phone access than men, women in Africa were also 23 percent less likely than men to have access to the internet in 2016. A financial inclusion opportunity is lost as mobile phone operators tend not to promote innovative financial literary "apps" in Africa.[29]

Reflecting a bias to formality, for years the only internationally-comparable indicators of financial inclusion were supply-side financial data sourced from national financial sector providers. These "access" data cover infrastructural density statistics but give only a partial picture of financial inclusion. For example, it is unclear whether bank accounts are active or inactive, if loans are productive or non-performing, and whether the un-weighted loan balances are swelled by a few large loans to big businesses. There is no information on the *quality* of financial services, only that there are services.[30] The provider data has recently been supplemented by survey data on usage, ranging from globally comparative cross-country data to country-specific surveys (see Aron, 2017). All contain some information on branchless banking and mobile money. The "G20 Financial Inclusion Indicators" capture access, usage and quality of financial services. This reflects a general endeavour to harmonize and extend comparative access, demand, and qualitative data across countries.

In practice, the proliferation of mobile money services and the sheer numbers of new users actively signed up has become integral to achieving ambitious targets under the 2011 Maya Declaration. A revised set of G20 indicators in 2016 has raised the prominence of mobile money, reducing the bias to formality. Indicators linked with mobile money are important components of the scoresheets for the

[27] Registration aids financial inclusion toward formal sector products. By contrast, an OTC transaction is conducted through an agent's account on behalf of the customer.
[28] International Telecommunication Union, ICT Facts and Figures 2016.
[29] See "Special Report, Business in Africa", The Economist, 16 April 2016, page 16 and "Continental disconnect", The Economist, 10 December 2016, pages 45-46.
[30] The IMF's annual data have, since 2014, included mobile money data.

Financial and Digital Inclusion Project (Lewis et al., 2017). Mobile technology including mobile money contributes to 13 of the 17 Sustainable Development Goals (SDGs), (GSMA, 2017).

4. An enabling policy and regulatory framework for mobile money

The regulatory environment shapes the viability and variety of business models, competition and innovation. Mobile money is "big business", but ironically, it is not easily profitable (Aron (2017).[31] Evidence suggests that "enabling regulation" promotes the profitability and sustainability of mobile money systems.[32] Critical regulatory lessons for mobile money systems are the following.

The first lesson concerns the nature of the "partnership models" for mobile payments: should they be bank-led or non-bank-led joint ventures? The initial qualms about licensing non-bank operators to offer mobile money services were misjudged. Some argued that non-bank-led mobile money deployment provides limited financial services to customers, contrasting with "full" financial inclusion. But this misunderstands the barriers to financial inclusion which mobile money has helped to solve and its pathways to later formal banking inclusion. A more cogent objection concerned licensing a non-bank that offers financial services with financial risks, but without being legally subject to prudential oversight. This prudential objection has been neatly surmounted: prudential regulation for mobile money is explained in Box 3.

In general, an MNO-led operation is better suited in terms of infrastructure, skills and incentives than a bank-led operation. MNOs have experience in building and operating an established network, there is brand recognition and marketing skills, and at low cost, mobile money can be appended to existing services (airtime and data provision) for current and new customers. MNOs benefit both directly and indirectly from the revenue from mobile services, helping to sustain their overall service. Banks lack these assets and incentives; bank-led models may be conservative and risk-averse in deployment (for instance, by not allowing a multi-tiered registration procedure, see below), and may even resist deployment if they consider mobile services to be in competition with their own services. By several metrics, the MNO-led ventures have been significantly successful than non-MNO-led ventures (GSMA, 2016a).

A second lesson concerns adopting more liberal regulation requirements for low-risk users of mobile money. Using *tiered* regulation that is proportionate to the specific risks of a service[33] can help achieve financial inclusion for low-risk customers without compromising financial integrity at higher levels of usage. For instance, liberal registration requirements can help promote adoption by poor customers who have a low threshold of transactions and pose little risk; these registration requirements can be geared up for the higher-risk customers with higher thresholds of usage. Adopting *proportionate* KYC procedures entails making use of *other* mitigation tools such as automated single transactional limits, daily and monthly transactional limits, and limits on stored balances. Flexible approaches can also be applied where national identity cards do not exist and poorer (low-risk) customers lack identity documentation.[34]

A third lesson concerns the regulation of agents. An appropriate design of the agent network structures and of the individual agent contracts is integral to the success of mobile money systems (Aron, 2017). An efficient agent distribution network has been crucial to M-Pesa's reaching scale in

[31] The benchmark to break even and show profit is about a million active subscribers, each performing at least one transaction per month. For accounts that are active on a 90-day basis, data from the GSMA State of the Industry report (2016) reveals that Kenya's M-Pesa was the first to break even in 2008, but that by 2016, only 35 of the global services in Figure 1 had reached "critical mass" (half of these being in SSA).

[32] See also Di Castri (2013) and GSMA (2017).

[33] See Klein-Mayer (2011).

[34] For example, in Fiji, reference letters from prescribed referees are accepted for registration.

Kenya.[35] To accelerate the spread of the service, *proportionate* regulation of agents is recommended. For instance, regulators may set standards for vetting and training of agents but leave the choice of agents and training to the mobile money providers. "Light touch" regulation is also beneficial where the central bank has a prerogative to inspect recruited agents but does not have to authorize agents before they can operate, thus avoiding bottlenecks.

A fourth lesson concerns the beneficial promotion of transparency through market conduct regulation for consumer protection. To benefit customers, prices and fees should be disclosed transparently, there should be simple clear contracts on customers' rights and obligations, and complex and expensive standards should be avoided for low value transactions. Customers should be made aware of effective complaints procedures. However, there are legal data privacy considerations concerning access to and use of mobile money records which have barely begun to be addressed. Issues of privacy and data protection straddle national privacy laws, telecommunications regulation, and financial regulation, but mainly laws concerning business practice. Compliance costs with regulated requirements for data privacy, including backups of data, should be assessed with the mobile money operators.

A fifth lesson concerns interoperability[36]. Creating the infrastructure when establishing mobile money services is expensive and compensation for the initial investments may be granted, such as exclusive contracts with the agent network. Ultimately, as other companies enter the market, competition policy should erode exclusivity and promote interoperability. Few countries have adopted interoperability (GSMA, 2016b). The execution of interoperability is technically complex especially in governance-constrained environments, and increases compliance costs, challenging the business viability of mobile money. The current position seems to be that interoperability will in due course become a desirable (market-led) goal with mature and viable deployments with strong and active customer bases.

5. The economics of mobile money - the micro-view

Mobile money potentially helps ameliorate several areas of market failure in developing economies.[37] The mobile money storage and payments system, and its potential linkages to bank savings accounts, micro-insurance, and loans via algorithmic credit scores, could affect households and businesses through several different channels.

5.1 Reducing transactions costs

Mobile money reduces the transactions costs of sending and of receiving money, especially with inadequate and expensive transport infrastructure. Transactions costs include the *transport costs* of travel e.g., to a bank, utility company or government office; the *travel time* and the *waiting time* in long queues; the *coordination costs* between individuals, between firms and suppliers or customers, and between government and individuals, which can be extensive in time and money lost; and the costs of *delays* and "*leakages*" through corruption or middlemen, acting like a *tax* (or complete loss through *theft* from insecure methods of money transfer). There is an *opportunity cost* to lost money and time.

[35] The cost of managing an agent network accounts for over half of total revenues. Successful providers have decreased the cost using appropriate incentives for more *active* agents (GSMA, 2017).
[36] Interoperability allows money transfers between two accounts at different mobile money schemes, or the transfer money between accounts at mobile money schemes and accounts at banks (Scharwatt et al., 2015).
[37] See Karlan et al. (2016) on market failure in a more general context of financial services.

The money could have been invested, spent or saved; the time could have been spent in productive activities. The automated delivery of cash transfers, wages, social security funds and private remittances by electronic transfer increases the *certainty* of the *timing* of cash receipts which helps *planning*.

5.2 Reducing asymmetric information and improved transparency

Moving cash from under the mattress into an electronic account turns it into *recorded* cash. Every deposit, withdrawal, transfer or payment transaction through mobile money creates a recorded financial history. This enhances financial transparency and reduces asymmetric information. Asymmetric information and the fixed costs of servicing an account lie at the heart of the failure of the formal banking sector to advance credit to poor customers who lack collateral and financial histories. Linking algorithmic credit scores and the granting of small loans was discussed above.

Electronic payment records potentially protect consumers against theft, fraud and misinformation. Greater transparency helps regulate the service through the dissemination and posting of information on transactions costs, thus promoting competition. Such protection reduces transactions costs for consumers and may increase growth of business through trust; Radcliffe and Voorhies (2012) note how the "anonymity of cash" may inhibit trust between traders and new vendors. Recorded transfers with appropriate ID documentation ("know your customer") facilitates far cheaper international remittance transfers.

5.3 Changing the nature of saving and increasing saving through digital means

There are several motives for saving. Life-cycle motives compensate for differences in timing between income and expenditure streams, and these include saving for education, leisure, marriage, consumer durables, housing purchases, retirement and funeral expenses. Precautionary motives (buffer stock saving) reflect the uncertainties of future income and expenditures, and include saving for unemployment, illness, accidents, natural disasters and risks associated with old age. Finally, there is saving for a bequest motive, to give gifts in one's lifetime or to leave a legacy to heirs. Saving thus helps to allocate consumption over time, and to reduce risk.

For the unbanked poor, their "immersion in physical cash creates considerable frictions in their financial lives" (Radcliffe and Voorhies, 2012). Cash-based households have informal savings options, which carry risks of theft or "liquidation": cash under the mattress; accumulation of assets such as jewellery or livestock; and storing savings with informal savings groups. Loss of savings in this manner is common. Mobile money electronic accounts offer safe storage of cash, though without the payment of interest.

Another advantage is privacy. Compared with cash receipts, the reduced observability of the timing and sizes of mobile transfers and the accumulated electronic balances, could protect savings for the recipient. This has proved important in empowering female mobile money users. Moreover, in an economic psychology literature on how the poor could be encouraged to accumulate savings, for example, the use of "commitment" savings accounts (Dupas and Robinson 2013), mobile money accounts offer a practical template.

5.4 Risk and insurance

Living standards of the poor are at risk of multiple *communal shocks* including flooding, droughts, pestilence, other natural disasters, sometimes conflict, and medical epidemics; and *idiosyncratic shocks* including theft, damage to the homestead, illness and death in the family. There are very limited opportunities for insuring against these risks. Formal insurance is typically absent, but family, clan and

network ties can create informal insurance networks, ameliorating such risks by periodic transfers and monitored by trust relationships amongst members of the network (De Weerdt and Dercon 2006). Jack and Suri (2011) suggest several ways by which mobile money can facilitate risk-spreading. The geographic reach of networks can enlarge. Timely transfers of money can arrest serious declines that may be impossible or hard to reverse. The mobile money technology allows small and more frequent transfers of money that allow a more flexible management of negative shocks. Thus, informal insurance networks may function more effectively. In turn, more efficient investment decisions can be made, improving the risk and return trade-off. Where mobile money develops sufficiently to allow access to micro-insurance, there is potentially an additional buffer against negative shocks.

5.5 Incomplete property rights, changing family dynamics and changing social networks

Women or minority groups may face limitations in their opportunities and their access to property, an aspect of inequality, and often resulting in more widespread economic inefficiencies. Mobile money could change bargaining power within the family. Greater privacy may influence both inter-household allocations (Jakiela and Ozier, 2016) and intra-household allocations (Duflo and Udry, 2004). If the nature of expenditure by gender differs (Chattopadhyay and Duflo, 2004), there could be welfare changes in the household.

Mobile money could change the nature of social networks. The size of networks could be expanded with the greater geographical reach of the transfer mechanism. The cohesion of a network could be strengthened or weakened. The reduced transactions costs of remittances might create a more liberal attitude to migration from the homestead (Jack and Suri, 2011), though distant migrants are less observable and accountable. There is huge scope for expanding research on network formation or dissolution, and on migration and remittance decisions, using mobile money transactions data (Chuang and Schechter, 2015).

5.6 Improving other aspects of economic efficiency

The combination of better communication and coordination with mobile phones[38] and instantaneous mobile payments could improve business planning and efficiency. Mobile payments facilitate trade. Access to credit, informally and through banking services linked to mobile money, can improve investment decisions. Improved risk-sharing and cheaper, secure, long-range remittances can expand the scope of labour decisions to encompass higher-risk but higher-return occupations, or migration to higher-return labour markets (Suri and Jack, 2016). There could be better allocation of savings and labour within the household and in businesses, and more efficient investment decisions affecting agriculture and business, and education and skills. Returns to investment could rise, with a feed-back to greater savings.

6. Empirical evidence from the micro-literature[39]

The rapid global growth of payments, transfers and international remittances, speaks of mobile money providers satisfying a demand for financial services not previously adequately met. This *revealed preference* suggests a net welfare improvement. Moreover, there could be a *larger* total than private benefit, as greater connectedness in the system occurs with each adoption. *But are empirical studies able to measure the economic benefits and these externalities?*

[38] The use of mobile phones gives access to information, such as weather forecasts, agricultural prices, agricultural extension advice, and health and education advice, likely to improve resource allocation.
[39] This section is a summary of detailed analysis in Aron (2017, 2018).

Given its novelty, few academic studies have examined the economics of mobile money. The bulk of empirical work employs survey data at the household or firm level. To reach robust conclusions on the economic benefits, the bar is set very high for empirical analysis. First, it is important to *analyse the appropriate data*, but often this is hard to achieve. Second, there are considerable *methodological challenges* in the empirical work, so that results need to be carefully assessed, and not taken at face value.

6.1 Challenges for data

Some data are unobservable. Empirical regressions will be mis-specified when omitting hard-to-measure variables linked to mobile money, such as spill-over learning effects in the community, and technological and quality changes. Important "observables", such as education (where quality is not assessed) and wealth, are typically poorly measured, which may exacerbate the biases.

Institutional and political regime changes affect the uptake of mobile money. For example, adoption is enhanced with more liberal registration requirements below a low threshold of use. In Côte d'Ivoire, the cessation of conflict and onset of greater growth and stability from 2012 was a key to driving mobile money adoption (Pénicaud and Katakam, 2014). There are likely to be shifts over time in the relevance of determinants e.g. cheaper, more capable smartphones widen access and ownership. It is possible, in principle, to test empirically for whether the effects of the variables alter with shifts and regime changes.

Data may be proprietorial, and it may be difficult to design surveys optimally in advance. Against these difficulties, if privacy concerns can be overcome, new access to a rich seam of "big" data, the administrative mobile money transactions from business and individuals, represents an enormous research opportunity. Mobile money payments data could be used to help forecast hard-to-gauge household assets and expenditure that otherwise rely on self-reported data (Blumenstock et al., 2015a), to derive proxies for migration patterns from geotagged data (Blumenstock, 2012) and explore social networks, relevant for work on remittances (Aker and Blumenstock, 2015).

Finally, definitional ambiguities could cause mis-counting when measuring mobile money "usage" itself. If the precision of this variable is compromised, measurement bias is introduced into the empirical work. Using the *number of mobile money accounts* or the *number of registered customers* may induce multiple counting of the same individual if several accounts are held with different providers. If registered customers are inactive (and globally two-thirds of registered accounts are inactive with a generous 90-day definition), this will exaggerate the true participation, see Figure 8. Where *unregistered* customers intensively use the service, as in over-the-counter (OTC) services, overall usage will be under-estimated.

6.2 Challenges for empirical methods

The quantitative empirical work on mobile money falls into two categories: studies which assess the determinants of the *adoption* of mobile money (i.e. where a proxy for usage of mobile money is the dependent variable) and studies of the *effects of mobile money on micro-economic outcomes* (i.e. where usage of mobile money is *not* the dependent variable). Examples of the latter include whether mobile money promotes improved risk-sharing, food security, consumption, business profitability, saving and effective use of cash transfers.

Research on mobile money faces two "selection" problems, raising the problem of ambiguous causality[40] in empirical analysis. The "roll-out" of mobile money by MNOs and their agents may not be random if they choose areas to operate in based on household and village characteristics. For instance, if the wealth of a village determines agent selection into that village (and that wealth is not properly controlled for in regressions) this will exaggerate the apparent effect of mobile money in promoting consumption because it is in part representing the wealth of the village. It is difficult to disprove self-selection by the agents toward more profitable locations.[41]

A second selection problem is undisputed: adoption of mobile money by individuals *is* influenced by factors both observable (e.g. education, wealth, urban dwelling and the use of banking services) and unobservable (e.g. susceptibility to risk, community learning spill-over effects and changes in technology preference) that may also be correlated with mobile money use. Thus, it is difficult to establish one-way causality using the above-mentioned data measures of usage of mobile money.

These selection problems have meant that the dominant empirical methodologies in this field are Randomised Controlled Trials (RCT), quasi-experiments with a Difference-in-Differences estimation strategy or the non-parametric method of Propensity Score Matching, and Instrumental Variables. These are described in Box 4. The choice amongst these methods is not uncontroversial. The methods have differing degrees of success in dealing with heterogeneity[42] at the individual or household level. Another consideration is whether results can be "scaled-up" or "transported" to allow generalisation to other contexts. Since institutional structures, regulation and demand patterns differ across countries, such generalisations of evidence need to be made cautiously. Moreover, the societal benefit when also taking account of positive externalities can often be greater than the sum of the individual benefits. These econometric modelling difficulties imply that the conclusions drawn are often suggestive only.

6.3 Assessing the evidence

A detailed, technical analysis of a range of studies is presented in Aron (2017, 2018). The best of these studies exploit panel (or longitudinal) data where a set of individuals is followed over time providing multiple observations on everyone in the sample. Amongst the most convincing analyses of the impact of mobile money are the *Difference-in-Differences* analyses (see Box 4) which demonstrate how mobile money has fostered improved *risk-sharing* amongst informal networks after large shocks. The proposed mechanism stems from the lower transaction costs when sending mobile money. Ease and security of sending remittances from afar has influenced the size of transfers, how frequently they are sent and the diversity of the remitters. The focus in these studies is not on the direct effect of mobile money usage on welfare, but rather on how mobile money usage *interacts* with a negative income shock such as from a drought or flood, while controlling for household characteristics.[43]

---

[40] Technically, this is an 'endogeneity problem', which in econometrics occurs when an explanatory variable is correlated with the error term, because of simultaneous causality, omitted variables and/or measurement error. There are several statistical methods that aim to correct the resulting bias in the regression estimates (Box 4).

[41] Several authors contend there is little statistical correlation between agent "roll-out" and household observable characteristics that might have been associated with future outcomes; but they use partial (one at a time) correlates only, which are not decisive (for a critical discussion, see Aron (2018)).

[42] Heterogeneity refers to the variation across surveyed individuals, some of which can be observed and controlled for (e.g. individuals differing by age and education), but some of which is difficult to measure (e.g. the changing technological preferences of individuals). Thus, omitted heterogeneity is an omitted variable, and hence a kind of endogeneity (see Box 4).

[43] The best of these studies exploits the properties of panel data to remove sources of unobserved *time-invariant* household heterogeneity using household fixed effects (see Box 3), include location-by-time dummies and rural-

In Kenya, Jack and Suri (2014) find total consumption of Kenyan mobile money users is unaffected by a range of negative income shocks while for those who do not use mobile money, their consumption drops by 7 percent. The effect is more evident for the bottom three quintiles of the income distribution. For Tanzanian mobile money users, a similar set-up by Riley (2016) further examines the potential beneficial spill-over effects of mobile money to the village community following an aggregate shock.[44] The author finds that in the absence of a shock, mobile money users share remittances with the village resulting in per capita consumption of everyone in the village increasing. After an aggregate shock, those households using mobile money benefit from an 8-14 percent increase in consumption compared with non-users, which cancels the effect of the negative shock on users; but here there are no spill-over effects to the community of non-users. These benefits to users and to communities are found to be highest in rural areas and to decrease sharply with distance to the nearest mobile money agent. [45]

On mobile money adoption, the Ugandan panel study of Munyegera and Matsumoto (2016a) deserves attention, supporting widespread qualitative evidence that education and wealth drive adoption, but finding no gender or age effect for rural adopters. On the effects of mobile money on saving, several studies claim the *beneficial* influence of mobile money on reported savings (by saving method), and on saving flows (Demombynes and Thegeya (2012), Munyegera and Matsumoto (2016a), and Mbiti and Weil (2016)). However, the results are compromised by problems of ambiguous causality, and no robust and conclusive results can be reached. Two RCT studies in Mozambique and Afghanistan (Batista and Vicente, 2016; Blumenstock et al., 2015b) suggest saving did not increase though the saving method switched to mobile money; but these studies use small and specialised samples and are probably not generalisable.

Far less satisfactory are several (non-RCT) welfare studies reviewed, where results are generally judged unreliable by Aron (2018). Problems of ambiguous causality for the mobile money usage dummy are centre-stage, and the use of a range of methods[46] to mitigate this are not always convincing. Two of the stronger studies are for Uganda and Kenya. A Ugandan panel study suggests an improvement in consumption for mobile money users (Munyegera and Matsumoto, 2016a); the result when instrumenting for the mobile money usage dummy casts strong doubt on the claimed result, but it has some support from a propensity score analysis (see Box 4 on these methods). A panel study for Kenya by Suri and Jack (2016) suggests consumption growth for male-headed households was negative and of female-headed households was positive with access to mobile money, but the result is tempered by probable bias, see Aron (2018)[47]. They draw implications for the reduction of poverty (suggesting 2 per cent of Kenyan households were lifted out of poverty), and shifts in occupations out of farming, particularly for female-headed households. However, if there is unobserved heterogeneity of the type discussed above, e.g. if wealth, which is not controlled for, is correlated with mobile money services, then they may be over-estimating the reduction in poverty.

A convincing RCT welfare study by Aker et al. (2016) finds improvements in household welfare after drought for the recipients of cash transfers through mobile money accounts in Niger, one of the poorest countries. Intra-household bargaining power for women was promoted[48] and their productivity improved by reduced transport costs, travelling and queuing time. Recipients were more

---

by-time dummies to help control for *time-varying* heterogeneity and include appropriate controls for household characteristics.

[44] The shock could be either a self-reported shock such as a drought or flood, or a measure of rainfall deviations from a long-term mean.

[45] It remains possible that *time-variant* household heterogeneity (e.g. from changing risk preference or changing technology preference) may still confound the results, see Aron (2018).

[46] Poor instrumentation and a lack of balanced panel data are problems here.

[47] This study is at its most convincing in the *differenced* specification for consumption; but even there, bias arises from the limited control of heterogeneity (Aron, 2018).

[48] Cash-transfer recipients were able temporarily to conceal the arrival of the transfer.

likely to cultivate and market those cash crops conventionally grown by women; they also had lower rates of depletion of durable and non-durable assets. Household and child diet diversity was 9-16 percent higher among households who received mobile transfers, mostly due to increased consumption of beans and fats, and children consumed a third more of a meal per day. Generalisability of this study is difficult; the authors emphasise that the mobile money "infrastructure" must be working well to reap the benefits. Repeating such RCT studies across many locations, cultures, continents and time periods may help reinforce the conclusions and generalisability.[49]

7. Conclusions and recommendations

Atkinson (2015) has argued that economic inequality is often aligned with differences in access to, use of, or knowledge of information and communication technologies. He stressed that researchers, firms, policymakers and governments have the possibility to shape the direction and path of technological change. Aid agencies, other donors, charitable foundations and international agencies play a key role too in the beneficial growth of mobile money and the associated financial inclusion (Aron, 2017, Section 11). Creative coalitions and the investment in multi-stakeholder partnerships can prompt deeper change, learning and practical action (Oxford Martin School, 2013).

Climate change:
Recommendations for Donors and Governments

Spill-overs from mobile money reduce the risks of climate change.

- Population growth projections for Africa are the highest globally (Harper, 2016). Promoting widespread adoption of affordable solar systems (Box 1), could significantly ameliorate the effect of energy use on climate (quite apart from the improved health, welfare, educational and other advantages).[50]

***"Enabling" regulation*:**
Recommendations for Regulators and Governments

Evidence suggests that "enabling regulation" promotes the profitability and sustainability of mobile money systems (di Castri, 2013). In turn this will sustain and enhance the gains in financial inclusion.

- Regulators face a fine balance between encouraging innovation and commercial viability - and enabling competitiveness and consumer protection.[51] Rather than each country "reinventing the wheel", the winning regulatory lessons for different mobile money models should be shared and reinforced (e.g., Box 3), while aligning with G20 principles and international standards.
- Interoperability is a desirable goal for mature deployments but is technically complex especially in governance-constrained environments: the timely sharing of comparative regulatory lessons is important to assess and address properly the new risks posed by interoperability.

[49] On the challenge of scalability for RCT studies and "transporting" results more generally to other contexts, see Aron (2018).

[50] M-Kopa, a recent start-up (Box 2), claims a 380,000 tonnes reduction of CO_2 output to date, based on 1.3 tonnes of CO_2 reduced per M-Kopa Solar system over 4 years.

[51] Short-term monopoly power to enable Safaricom to establish an exclusive agent network followed by erosion of that exclusivity toward greater competition is an example of Kenya's pioneering enabling regulatory approach.

- Regulation straddles several branches of the existing law for business, telecommunications and prudential protection, and mobile money systems have relationships with multiple agencies in government (e.g. the different regulators, public utilities, the central bank ministries of telecommunications, finance and those dealing with pensions, salaries and social security) as well as the private sector. This argues for policy coordination with an inter-agency committee to achieve the necessary regulatory balance, and to help scale mobile money by giving impetus and greater certainty to the private sector.[52]
- Non-bank-led mobile money operations should be preferred to bank-led mobile money operations (Section 4). Regulation should discourage OTC mobile money services: they reduce the possibility of scaling-up for mobile money systems and reduce financial inclusion (GSMA, 2017).
- Issues of identification may be challenging in poor countries, especially for poor rural dwellers and women. Establishing a digital foundational identity (a national identity scheme) for KYC procedures could overcome barriers to usage, especially for rural dwellers and women (GSMA, 2017); the creative use of biometrics should also be explored.
- *Proportionate* regulation should risk-adjust services in segmented markets.[53] For instance, risk-based proportionate guidelines for anti-money laundering, combating the financing of terrorism, and maintaining customer due diligence procedures for *international remittances* are recommended by the Financial Action Task Force (FATF, 2013) to enhance financial inclusion. Similarly, graduated *registration* requirements promote financial inclusion for the poorest with limited usage without compromising financial integrity at higher thresholds of usage.
- Regulation should link payments records with protective regulation for consumers' rights, thus fostering trust in business and efficient payments networks. More generally, regulation should enhance the transparency of data use, pricing, credit terms and penalties for consumer protection, and provide complaints procedures for customers.
- The serendipitous appearance of hire-purchase credit through mobile money should be promoted but with safe-guarding regulation (e.g. Box 2).
- International remittances through mobile money should be encouraged (e.g. by refraining from taxing remittance outflows[54] and discouraging exclusive contracts with money transfer operators).[55] But creative implementation solutions are urgently needed to address the poor *local* compliance to international law in countries with weak governance, e.g. Somalia (Makin and Clark, 2014).
- Critical to the success of mobile money systems are the agent networks, expensive to set up with training and which consume over half of revenue in fees and monitoring. Lessons from successful networks emphasise incentive-compatible contracts with appropriate training and monitoring toward *active* agents[56], and the appropriate liquidity, reliability and density of agents. Governments could use their own infrastructure to enhance density (e.g. post office banks) and engage in *proportionate* regulation of agents (Section 4).

Data privacy:

Recommendations for Governments and Regulators

[52] see USAid (2012).

[53] This needs to be addressed early on as constraints on adoption from stringent registration requirements may heavily impede adoption of mobile money by the poorest, making it unsustainable.

[54] See Ratha (2017) on nine reasons not to tax outwards remittances.

[55] Promoting mobile money for lower cost international remittances could re-channel "informal" remittances through official channels, raising recorded remittances and improving their measurement and management.

[56] Agents with the right incentives in their contracts can help make customers *active* by promoting customer transactions, particularly where financial literacy is low. Evidence shows this makes a major difference in sustained use after adoption, Aron (2017).

Who owns the data? Legal issues on data privacy concerning access to and use of mobile money records have hardly begun to be addressed. Monopolists that use data to profit at the expense of consumers could exacerbate inequality. Reducing asymmetric information should benefit both sides.

- There may be poorly developed procedures for transparently obtaining informed data consent.
- Little is known about the proprietorial algorithms used to provide credit scores, and this should be researched with a view to refinements. It is possible there may be biases on gender or minorities where non-traditional data are used for credit scoring (Francis et al., 2017), where remedial regulatory action may be required.
- Legislation was enacted only in 2004 requiring US credit reporting agencies to provide extensive credit score (FICO) information at a customer's request. Such privacy issues will have to be addressed by regulators for mobile payments credit scores, yet regulatory agencies may be weak or non-existent.
- Data trusts have been recommended in the UK to improve trust and ease around the secure sharing of anonymised data (Hall and Pesenti, 2017), and is an idea worth pursuing for mobile money data.

Best practice empirical analysis on mobile money:
Recommendations for Academics

From the empirical survey of Aron (2018), lessons have been distilled for the best practice in empirical analysis of mobile money. The result could be more reliable conclusions, bolstering the case for significant government and donor support, and commercial investment.

- Adoption/usage of mobile money should be correctly measured; phone ownership should be disentangled from usage of its services (mobile money) in empirical models.
- The greatest weight should be given to micro-studies using balanced panel data which apply their considerable potential advantages for control of time-invariant and some time-variant (e.g. by location) heterogeneity, and which include appropriate controls for time-variant household characteristics.[57]
- Given drawbacks with all the techniques, studies should apply and contrast a range of techniques, and enhance robustness testing and testing of the validity of instruments.
- Panel data studies should ascertain the size and direction of the bias of OLS methods (Aron, 2018). This gives useful upper or lower bounds on estimates, strengthening policy conclusions from noisy micro-studies.
- Structural breaks can make findings hard to generalise: spill-over effects, technological improvements and regime changes introduce potential non-linearities or parameter shifts, and these should be tested for in empirical work.[58]
- Important social dimensions should be illuminated by testing for differences between more and less affluent households and other potential types of non-linearity or interaction effects (e.g. urban versus rural, by occupation, by education level and by gender).

Improving data, data access and promoting big data research:

[57] Controlling for heterogeneity and finding exogenous instruments in cross-sectional studies is a heroic exercise: these studies are likely to be compromised and unreliable.
[58] Micro-studies ignoring spill-over effects may be picking up only *part* of an effect, and hence be a poor guide to the economy-wide effect of a policy; in this way, earlier estimates could *underestimate* the later impact of mobile money.

Recommendations for Academics, Central Banks and MNOs

Mobile money operations provide a huge new stream of data for innovative analysis, largely untapped, that can both support the case for investing in mobile money and provide useful tools for central banks and others. However, poor quality data and sub-optimal data collection severely compromise the conclusions that can be reached from empirical work.

- Panel survey data collection should be encouraged wherever possible for best practice analysis.
- Especially when "rolling out" new mobile money services and related products (pension, credit and insurance), cooperation amongst donors, central banks, the MNOs and academics should aim to harness longitudinal data in appropriately defined surveys, for a *timely* and best practice analysis.
- Central banks should sub-aggregate the underlying data they collect from MNOs for use in research and monitoring, such as "now-casting" for a contemporaneous view of economic activity (given the long lags in the national accounts).
- Anonymising procedures should be accepted and formalised by central banks and related authorities, so that benefits could be reaped from facilitating diverse academic research analysis using anonymised disaggregated data.
- A cooperative provision of the huge volume of recorded "administrative" transactions data across countries from many operators could enable innovative research applications. Some examples are:
    - Geo-tagged mobile payments data could help explore the little-studied areas of social network formation or dissolution, and migration and remittance decisions (thus overcoming problems from self-reported survey data, often rife with measurement error).
    - Mobile money data with detailed expenditure transactions, could help predict data on welfare indicators like socioeconomic status and asset ownership (thus overcoming problems from self-reported wealth and expenditure from surveys, often rife with measurement error).
    - There is a unique opportunity currently to investigate new products of digital credit (Francis et al., 2017): are they are fit for purpose and more successful than traditional micro-credit in improving living standards and productivity, rather than encouraging over-indebtedness?
    - Equally, highly topical research is needed on the new micro-insurance products rolled out through mobile money.
    - Micro-studies could provide a reality check for policy-makers, in evaluating bold claims for digital finance and mobile money by macro-studies[59] based on optimistic assumptions that link digital finance and economic growth and inequality (e.g. on barriers to adoption, the welfare impact, the take-up of diversified services including credit, and the government's tax take).

Financial inclusion:

Recommendations for Governments and Donors

The traditional *definition* of financial inclusion - providing a full suite of *formal sector* banking services – has drastically hampered inclusion. Properly accounting for financial inclusion through mobile money can bolster the case for helping to support diversity and innovation in mobile money systems.

- Defining financial inclusion to embrace gradualism in institutional change should replace the "bias to the formal", allowing for "tiers" of semi-formal financial services:

[59] For instance, McKinsey (2016) applies a proprietary general equilibrium macroeconomic model to macro-data for seven countries, extrapolating the results globally for all emerging market countries; they predict that adoption and use of digital finance (banking in general) could increase the GDP of all emerging economies by 6 percent, or $3.7 trillion, by 2025. However, micro-studies surveyed in Aron (2018) show how difficult it is to quantify outcomes accurately and scale up from individual studies of different countries to make policy pronouncements.

    - Active mobile money accounts should be included in the quantification of financial inclusion, even if not linked with a bank account.
    - Credit products via mobile money could provide the basis for a *new* financial inclusion indicator: the creation of credit scores for the first time for the unbanked based on real-time electronic mobile money records, potentially giving access to bank loans; and, without a bank account, hire-purchase credit that allows an accumulation of collateral against further loans (Box 2).
- A national financial inclusion plan can help sustain or mobilise the political will to support the scaling up of mobile money, the inclusion of women, promoting digital literacy and a national digital identity.
- Governments, donors and NGOs could coordinate to enhance financial literacy and education along with the mobile money roll-outs, to explain consumer protections, the security and privacy of accounts, the value of saving, and potential access to pensions, credit and insurance.[60]
- Addressing literacy and identification barriers for including hard-to-reach rural and female users, could improve the education and nutrition of children via the enhanced bargaining power of female and minority users with private mobile money accounts (and significantly scale-up mobile money).
- Subsidies or other support needs to address the limited internet coverage and expensive data in many African countries (Figure 7); valuable opportunities for inclusion are lost, as then few MNOs will develop innovative applications for smartphones to improve accessibility for the financially illiterate and to "nudge" commitment saving.
- Research suggests insurance is the key constraint, rather than credit, for small-holder agricultural investment decisions (Karlan et al., 2014). Incipient micro-insurance products though mobile money, centred on objective measures such as rainfall insurance to help deal with adverse selection/moral hazard problems, should be fostered.

Scaling up and providing complementary inputs:
Recommendations for Governments and Donors

Digital finance is one of the few areas with a real revolution in services, leapfrogging over deficient traditional infrastructure. Network economies of scale and positive externalities are good reasons for donors and governments to promote mobile money to overcome the fixed cost threshold and reach scale. But new access to financial services is compromised by economic obstacles, especially corruption, lack of electricity generation, and poor road infrastructure. Without complementary action to address such constraints increasing returns could be limited far below their potential.

- The micro-benefit established by several studies could be *multiplied greatly* through spill-over effects in the presence of well-functioning general infrastructure and transparency (lack of corruption) – especially if mobile money itself reduced corruption.
- Governments, NGOs and donors can fund pilot projects that examine the impact, benefits and commercial success of mobile money and related financial products like insurance, savings and credit, e.g. for poor farmers, yielding lessons for scaling-up.
- Rather than "killing the golden goose" with high tax rates[61], with the demonstrated welfare and financial inclusion benefits, the case should be examined - apart from enabling regulation - for

[60] For example, the tendency to cash-out quickly and not to use a broader payments platform undermines the scaling-up of mobile money.
[61] GSMA research published in 2017 showed that mobile money in one country is now taxed at a higher excise duty rate than alcohol and cigarettes.

public interventions such as subsidies, short-term tax relief, and investment allowances for the industry itself.

- Scaling up would be enhanced through the efforts of donors and governments to employ bulk payments of wages, social benefits, cash transfers, and pensions using mobile money (GSMA, 2017).
- Successful operatives in mobile money have diverse and growing broad payments platforms, so that facilitating business usage and encouraging international remittances with appropriate regulation, including donor-driven humanitarian assistance, helps scale-up mobile money (GSMA, 2017).

References

Aker, J.C. and J.E. Blumenstock. 2015. "The Economics of New Technologies in Africa.". The Oxford Handbook of Africa and Economics. Volume 2: Policies and Practices. Eds. Célestin Monga and Justin Yifu Lin. Oxford: OUP.

Aker, J.C., R. Boumnijel, A. McClelland, and N. Tierney. 2016. "Payment Mechanisms and Anti-Poverty Programs: Evidence from a Mobile Money Cash Transfer Experiment in Niger." Economic Development and Cultural Change 65(1):1-37.

Aron, J. 2018. "Mobile Money and the Economy: A Review of the Evidence." World Bank Research Observer 33 (2):135–188.

Aron, J. 2017. "'Leapfrogging': a Survey of the Nature and Economic Implications of Mobile Money." CSAE Working Paper 2017-2, Centre for the Study of African Economies, University of Oxford.

Atkinson, A.B. 2015. *Inequality: What can be done?* Cambridge, Massachusetts: Harvard University Press.

Batista, C., and P.C. Vicente. 2016. "Introducing Mobile Money in Rural Mozambique: Evidence from a Field Experiment." CSAE Conference 2016: Economic Development in Africa, Oxford https://editorialexpress.com/conference/CSAE2016/program/CSAE2016.html#75

Blumenstock, J. 2012. "Inferring patterns of internal migration from mobile phone call records: evidence from Rwanda." Information Technology for Development 18(2):107-125.

Blumenstock, J.E., G. Cadamuro and R. On. 2015a. "Predicting poverty and wealth from mobile phone metadata." *Science* 350 (6264), 1073-1076.

Blumenstock, J.E., M. Callen, T. Ghani, and L. Koepke. 2015b. "Promises and Pitfalls of Mobile Money in Afghanistan: Evidence from a Randomized Control Trial." The 7th IEEE/ACM International Conference on Information and Communication Technologies and Development (ICTD '15), Singapore.

Chattopadhyay, R. and E. Duflo. 2004. "Women as Policy Makers: Evidence from a Randomized Policy Experiment in India," Econometrica 72(5):1409-1443.

Chuang, Y. and L. Schechter. 2015. "Social Networks in Developing Countries." Annual Review of Resource Economics 7: 451-472.

De Weerdt, J., and S. Dercon. 2006. Risk-Sharing Networks and Insurance Against Illness. Journal of Development Economics 81(2):337–56.

Deaton, A. 2010. "Instruments, randomization, and learning about development." Journal of Economic Literature 48:424-455.

Deaton, A. and N. Cartwright. 2016. "Understanding and misunderstanding randomized controlled trials." NBER Working Paper No. 22595, National Bureau of Economic Research, September, 2016. http://www.nber.org/papers/w22595. *See a non-technical version at*: http://voxeu.org/article/limitations-randomised-controlled-trials, Nov. 2016.

Demombynes, G. and A. Thegeya. 2012. "Kenya's Mobile Revolution and the Promise of Mobile Savings." World Bank Policy Research Working Paper no. 5988, March 2012.

di Castri, S.. 2013. "Mobile Money: Enabling regulatory solutions." GSMA, February.

Duflo, E. and C. Udry. 2004. "Intrahousehold Resource Allocation in Cote d'Ivoire: Social Norms, Separate Accounts and Consumption Choices." Working Paper 10498, National Bureau of Economic Research.

Dupas, P. and J. Robinson. 2013. "Why Don't the Poor Save More? Evidence from Health Savings Experiments." American Economic Review 103(4):1138–1171.

Federal Reserve. 2016. *Survey of Consumers and Mobile Financial Services 2016* Washington: Board of Governors of the Federal Reserve System, March.

Francis, E., J. Blumenstock, J. Robinson. 2017. "Digital Credit In Emerging Markets: A Snapshot of the Current Landscape and Open Research Questions." Center for Effective Global Action.

Greenacre, J. and R. Buckley. 2014. "Using trusts to protect mobile money customers." Singapore Journal of Legal Studies 59-78.

GSMA. 2017. "The Mobile Economy Sub-Saharan Africa 2017." GSM Association. www.gsmaintelligence.com

GSMA. 2016a. "Success factors for mobile money services: A quantitative assessment of success factors". https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2016/11/GSMA_Success-factors-for-mobile-money-services.pdf

GSMA. 2016b. "State of the Industry Report on Mobile Money: Decade Edition: 2006-2016." www.gsma.com/mobilemoney

Hall, W. and J. Pesenti. 2017. "Independent report: Growing the artificial intelligence industry in the UK." https://www.gov.uk/government/publications/growing-the-artificial-intelligence-industry-in-the-uk

Harper, S. 2016. "How Population Change Will Transform Our World." Oxford: Oxford University Press.

Iazzolino, G. 2018. " Digitising Social Protection Payments: Progress and prospects for financial Inclusion." Bath Papers in International Development and Wellbeing No 57/2018, The Centre for Development Studies University of Bath.

Jack, W., and T. Suri. 2011. "Mobile Money: The Economics of M-Pesa." Working Paper 16721, National Bureau of Economic Research.

———. 2014. "Risk Sharing and Transactions Costs: Evidence from Kenya's Mobile Money Revolution." American Economic Review 104(1):183–223.

Jakiela, P. and O. Ozier, 2016. "Does Africa Need a Rotten Kin Theorem? Experimental Evidence from Village Economies." Review of Economic Studies, Oxford University Press 83(1): 231-268.

Karlan, D., R. Osei, I. Osei-Akoto and C. Udry. 2014. "Agricultural Decisions after Relaxing Credit and Risk Constraints." Quarterly Journal of Economics 129(2):597-652.

Klein, M. and C. Mayer. 2011. "Mobile Banking and Financial Inclusion: the Regulatory Lessons." World Bank Policy Research Working Paper 5664, Washington D.C..

Lewis, R.J., J.D. Villasenor, and D.M. West. 2017. The 2017 Brookings Financial and Digital Inclusion Project Report: "Building a Secure and Inclusive Global Financial Ecosystem." Center for Technology Innovation at Brookings, Washington DC.

Lucini, B. Arese and A. Sharma. 2016. "Managing disaster response through mobile: Asia Pacific." GSMA Intelligence, November, 2016. https://www.gsmaintelligence.com/research/2016/11/managing-disaster-response-through-mobile/591/

Makin, Paul and Dick Clark. 2014. Report: Safe Corridors for Remittances FSD-Africa. https://www.gov.uk/.../Safe-corridors-Remittance-technology-options.pdf

Mbiti, I. and D.N. Weil, 2016. "Mobile Banking: The Impact of M-Pesa in Kenya," in National Bureau of Economic Research: African Successes: Modernization and Development, S. Edwards, S. Johnson and D. Weil (eds.), University of Chicago Press.

Munyegera, G.K. and T. Matsumoto, 2016a. "Mobile Money, Remittances, and Household Welfare: Panel Evidence from Rural Uganda," World Development, Elsevier, 79:127-137.

———. 2016b. "Banking on the Cell-phone: Mobile Money and the Financial Behaviour of Rural Households in Uganda." CSAE Conference 2016: Economic Development in Africa, Oxford https://editorialexpress.com/conference/CSAE2016/program/CSAE2016.html#75

Oxford Martin School. 2013. Now for the Long Term. The Report of the Oxford Martin Commission for Future Generations. Oxford Martin School, University of Oxford. October.

Pénicaud, C. and A. Katakam. 2014. State of the Industry 2013. GSMA Mobile Financial Services for the Unbanked. GSMA.

Ratha, Dilip. 2017. http://blogs.worldbank.org/peoplemove/why-taxing-remittances-bad-idea.

Radcliffe, D. and R. Voorhies. 2012. "A Digital Pathway to Financial Inclusion." http://ssrn.com/abstract=2186926 or http://dx.doi.org/10.2139/ssrn.2186926.

Riley, E. 2016. Mobile Money and Risk Sharing Against Aggregate Shocks. CSAE Working Paper 2016-16, Centre for the Study of African Economies, Oxford.

Rogoff, K.S. 2016. *The Curse of Cash.* Princeton, New Jersey: Princeton University Press, 1-248.

Scharwatt, C., A. Katakam, J. Frydrych, A. Murphy, and N. Naghavi. 2015. State of the Industry 2014. GSMA Mobile Financial Services for the Unbanked. GSMA.

Suri, T. and W. Jack. 2016. “The long-run poverty and gender impacts of mobile money.” Science 354(6317): 1288-1292.

USAid. 2012. http://www.citibank.com/transactionservices/home/public_sector/docs/Mobile_Money_Article.pdf

Villasenor, J. 2013. “Smartphones for the Unbanked: How Mobile Money Will Drive Digital Inclusion in Developing Countries.” The Brookings Institution, Issues in Technology Innovation 24:1-12.

Table 1: Global trends in international remittances and their costs

Global trends in remittances				
Region/country	*US$ billions*			
	2010	2014	2016	2018 (f)
All developing countries	**335**	**436**	**422**	**475**
East Asia & Pacific	96	121	123	135
Europe & Central Asia	38	52	40	51
Latin America & Caribbean	57	65	74	83
Middle-East & North Africa	39	54	49	56
South Asia	82	116	110	120
Sub-Saharan Africa	30	37	34	41
World	**468**	**598**	**573**	**642**
Global transactions costs of remittances				
Region/country	*Total average transactions cost of sending US$200(including fees and exchange rate margins) as % of amount sent*			
	2010q1	2014q1	2016q1	2018q1
East Asia & Pacific	9.3	8.3	8.3	7.6
Europe & Central Asia *(excl. Russia)*	8.3	8.2	7.5	7.4
Latin America & Caribbean	8.1	6.2	5.9	5.9
Middle-East & North Africa	8.2	8.3	7.5	7.3
South Asia	6.0	6.6	5.5	5.2
Sub-Saharan Africa	10.9	11.7	9.7	9.4
World	**8.7**	**8.4**	**7.5**	**7.1**
SDG 10c, targets a reduction in the cost of remittances	*Target of 3% by 2030*			

Sources: Remittance Prices Worldwide; World Bank Migration and Remittances Data, Migration and Development Briefs no. 24 to 29.

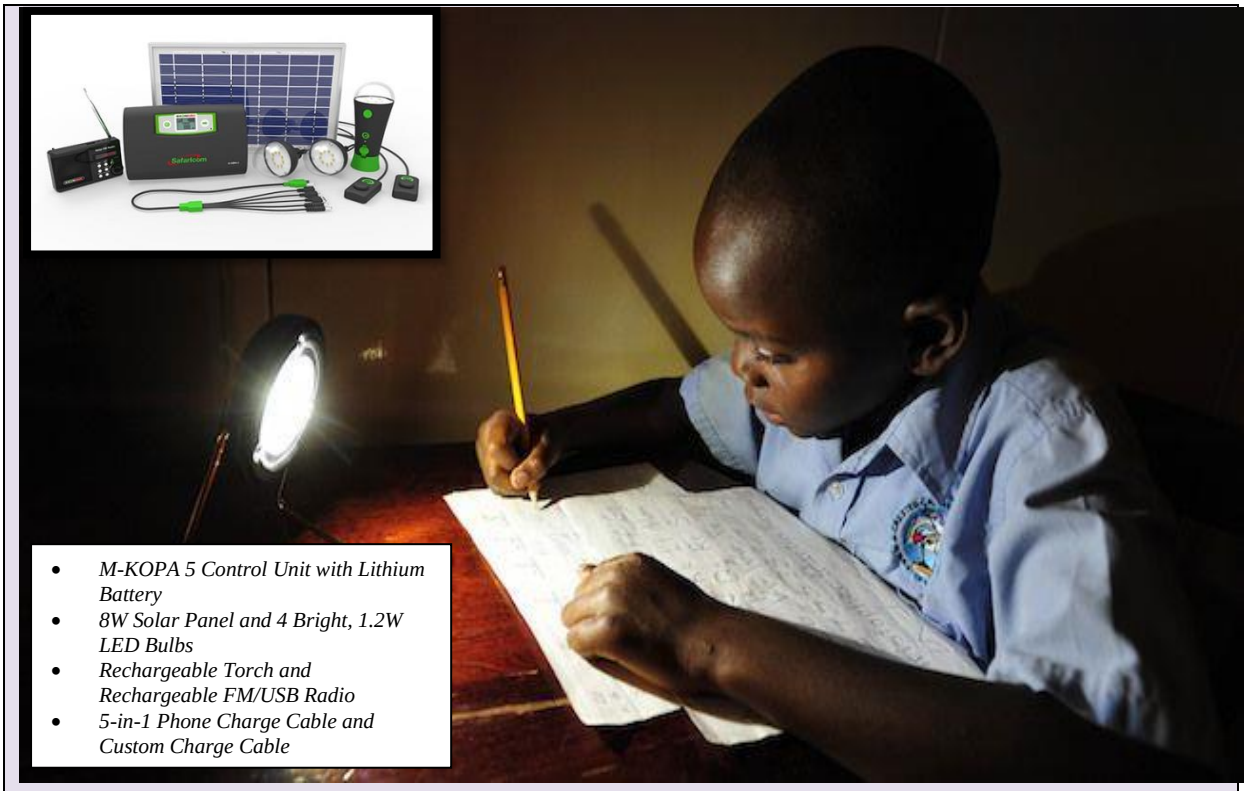
Note: Sustainable Development Goals (SDG) are a collection of 17 global goals set by the United Nations General Assembly in 2015, part of Resolution 70/1 of the United Nations General Assembly: https://sustainabledevelopment.un.org/sdg10

BOX 1: Characteristics of mobile money

The common characteristics of mobile money, see Di Castri (2013), are:

- it is electronic money issued on receipt of funds in an amount equal to the available monetary value;
- it is electronically recorded on a mobile device;
- the electronic value is redeemable for cash, and the electronic value may be accepted as a means of payment by parties other than the issuer (e.g. person-to-person transfers, retail payments and payment for services; government-to-person transfers (and receipts); donor-to-person cash transfers; and business transfers (and receipts));
- the electronic value is backed up by storage of equivalent funds in one or more banks depending on central banking or other regulations.

BOX 2: Hire purchase credit and collateral through mobile money



- *M-KOPA 5 Control Unit with Lithium Battery*
- *8W Solar Panel and 4 Bright, 1.2W LED Bulbs*
- *Rechargeable Torch and Rechargeable FM/USB Radio*
- *5-in-1 Phone Charge Cable and Custom Charge Cable*

"*Hire purchase credit*" through mobile money allows secure, remote purchases of costly durable items on a flexible pay-as-you-use basis using mobile payment, with the further advantage of *acquiring collateral* (and a positive credit score) by dependable customers for further upgrade products via credit.

The potential market for clean, renewable power via off-grid solar is 20m households in East Africa alone. About 80% of Uganda's population lack access to electricity and rely on kerosene and firewood for lighting. It is time-consuming to gather the wood and burning creates unhealthy pollution.

M-Kopa Solar (M for mobile, Kopa is Swahili for *borrow*), an equity-funded Kenyan solar energy company launched in 2012, installed over 500,000 residential solar systems in East Africa (Kenya, Tanzania & Uganda) by May 2017. Customers acquire the system for a small deposit, and with daily usage "credits" of about US$0.45 (saving almost a third of what they used to spend on traditional kerosene lighting and batteries), they gradually off-set the cost of the device. After a year of payments through *M-Pesa and related mobile money platforms*, customers own the system outright, and can remortgage their system in exchange for further products: upgraded solar sets, smartphones, televisions and fuel-efficient cooking pots (small refrigerators are in prospect). A technology platform (M2M) is used for processing payments, and for remote control and monitoring.

Start-ups in Rwanda (Mobisol), Ghana (PEG), Uganda (Fenix International) and Nigeria (Nova Lumos), have partnered with *MTN as a mobile payments platform* to provide solar systems.

Mutual benefits: the solar service improves the visibility, use and profitability of mobile payments companies.

BOX 3: Prudential regulation of mobile money

Mobile money is most successfully offered by non-bank operators such as mobile phone companies (Di Castri, 2013). The important question is how to regulate prudentially a *non-financial* institution for the protection of customers' money, and, potentially, the financial stability of the economy.

Custodial Trust accounts to protect customers' electronic money from provider insolvency

In Kenya, the Central Bank requires a partnership between the (service-leading) MNO and one or more prudentially-regulated banks. The partner bank is custodian for the customers' electronic funds but is not involved in the commercial deployment. The electronic value is fully backed up by pooled funds held in "trust" accounts or "escrow" accounts[a] which may be diversified across several banks to mitigate the risk of bank failure. Some jurisdictions allow investment in low risk securities like government bonds. Funds held on behalf of customers are ring-fenced from the issuer's funds and protected from claims by the issuer's creditors. If the *non-bank provider* becomes insolvent, the funds accrue fully to the consumers, in accordance with the regulatory procedures for that country.

Deposit insurance to protect customers against partner bank failure

The electronic mobile money accounts carry no deposit insurance as for a bank account. If the partner *bank* should become insolvent the legal position is that the deposit insurance[b] for the escrow bank account of pooled customers' funds accrues to the customers. But the insurance level is typically low (of the order of US$1000) and the pay-out applies once to the whole account. It is important that regulation should allow *pass-through protection* for *each* customer up to the insurance limit (as in the US for pooled custodial accounts). Raising the ceiling for deposit insurance on such pooled funds is advisable.

Intermediation and the payment of 'interest' to customers

Non-bank providers may not intermediate the electronic funds. However, the partner banks may intermediate the pooled funds by lending them, and in consequence, interest arises on the escrow deposits. In Kenya the interest is paid to charity, but by Trust Law, as stated explicitly in the Kenyan Guidelines, this Trust interest income could be allocated to the beneficiaries of the trust (i.e. the customers and agents), as has occurred in Tanzania since 2014. If customers were paid *pro rata* from Trust account interest income, given the inflationary degradation of their electronic deposits (interest is not paid), this could promote savings in electronic accounts.

Monitoring for financial integrity and financial stability

Moving from cash to recorded transactions in electronic mobile money accounts enhances financial integrity. Anonymity is reduced, and money becomes traceable.[c] Providers have stringent regulatory requirements to keep full records and backups. There are requirements for customer identification documentation. Partner banks must satisfy fiduciary responsibility concerning the Trust funds (with daily reconciliation of the Trust account and the e-money). Most systems have automated transactional limits as well as daily and monthly transactional limits, and limits on stored balances, and unusual behaviour can be detected by systems monitoring.

[a] Trust accounts are managed by Trustees on behalf of specific beneficiaries and governed by Trust law, in Common law jurisdictions. Escrow accounts are typically established in Civil law jurisdictions; the rights of the depositor (e-money issuer) and third person (mobile money account-holder) are determined by the terms of the contract of the escrow arrangement (Greenacre and Buckley, 2014).

[b] Many countries such as Rwanda and Ghana *do not yet have* deposit insurance schemes for bank accounts to protect consumers.

[c] Apart from the mobile phone number, a unique PIN identification is required for transactions, and the unique Mobile Station International Subscriber Directory Number (MSISDN) is recorded for each transaction.

BOX 4: Summarising the empirical approaches for mobile money studies

Randomised Controlled Trials (RCT)

Common in medical research, RCT was little used in economics before 2003. It has generated heated debate that is pertinent to the reliability of mobile money RCT studies. An RCT evaluates whether a specific, controlled change (here, the adoption of mobile money) has a discernible impact on a treated group relative to a control group. RCTs focus on small interventions that apply in certain contexts so that inferences for other settings, or even scaling up based on the results, may be invalid. Identifying a causal connection in one situation might be specific to that trial and not a general principle. The intervention itself, and the nature and quality of information provided about the intervention, can affect behaviour. The studied populations are typically small, so that an outlier can have a large distortionary effect. Deaton (2010) argues there are two stages of selection. In the first, researchers choose a group from the entire population that will in the second stage be randomly divided into the treated and control groups. The first stage is not random, but may be determined by convenience or politics, and therefore may not be representative of the entire population. Deaton and Cartwright (2016) further argue that randomisation does not *guarantee* that the treatment and control groups are identical except for the treatment, i.e. it does not guarantee that *other* causal factors are balanced across the groups at the point of randomisation.

Difference-in-Differences (DD)

A second approach, more widely-used in mobile money research, tests specific theoretical hypotheses using a DD estimation. This mimics an experimental approach by comparing *differences* in the *changes* of a control and a treated group after an intervention (e.g. the adoption of mobile money). It makes a restrictive assumption, that without the intervention, the average change in the outcome for the treated and control groups would have been identical. The DD method also assumes the intervention is random (i.e. no selection problems), and that linear relationships rather than non-linear ones hold. Typically estimates are made with repeated cross-sections or panel data on heterogeneous individuals for one or more periods before and after an intervention. A dummy variable for mobile money usage (equal to 1 if there is usage and zero if not) is included, and a set of variables to control for observable household and other characteristics. If the intervention is approximately random, then "fixed effects" dummies can be included to adjust for the unobservable (*time-invariant*) characteristics of these heterogeneous individuals (e.g. character traits linked with genetic variation). However, if there is *time-variant*, unobserved heterogeneity (e.g. learning from experience or the behaviour of others) this may only partially be mitigated with some additional controls, see Aron (2018).

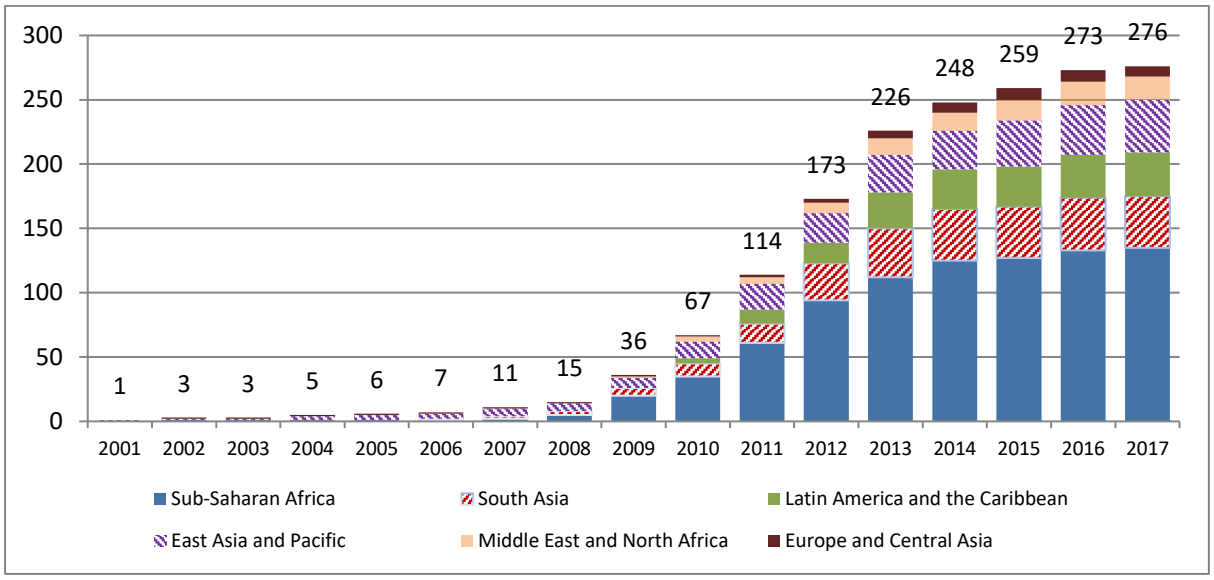
Propensity Score Matching methods

Several mobile money studies present supplementary evidence from Propensity Score matching methods. These methods mimic characteristics of an RCT in a non-randomised study, using non-parametric rather than regression techniques to estimate the effects of an intervention (e.g. use of mobile money) on outcomes between treated and control groups. The presentation of these results is typically rather opaque, and it is difficult to judge if they meet the demanding criteria for the technique to be valid, see Aron (2018).

Instrumental Variables (IV) methods

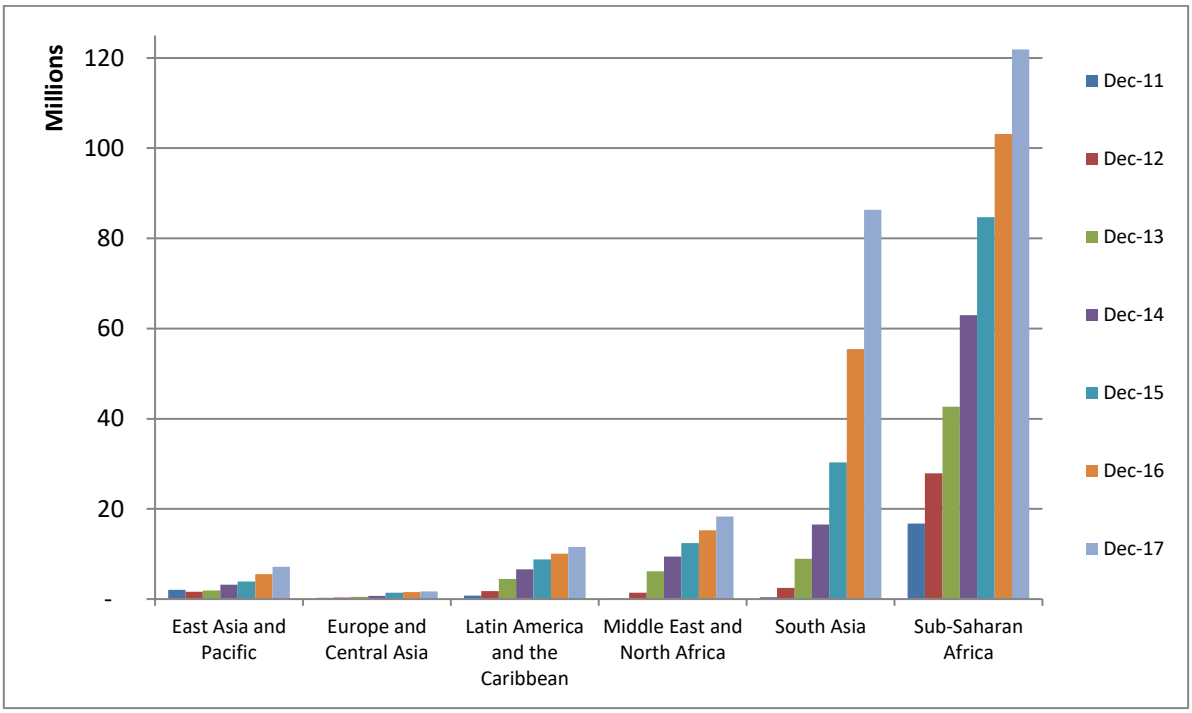
IV can be used for consistent estimation when it is suspected that the intervention (here mobile money adoption) is not random but correlated with other factors that may be poorly measured (like wealth) or unobservable (like changing technology preferences). Then the proxy for mobile money usage (typically a dummy equal to 1 if there is usage and zero if not) is replaced by the predicted value from a set of "instruments", see Aron (2018). Finding credible instruments for mobile money usage is a challenge. Several instruments have been used in the mobile money empirical literature, but statistical tests tend to find them weak, which may introduce bias.

Figure 1: Number of live mobile money services for the unbanked by region



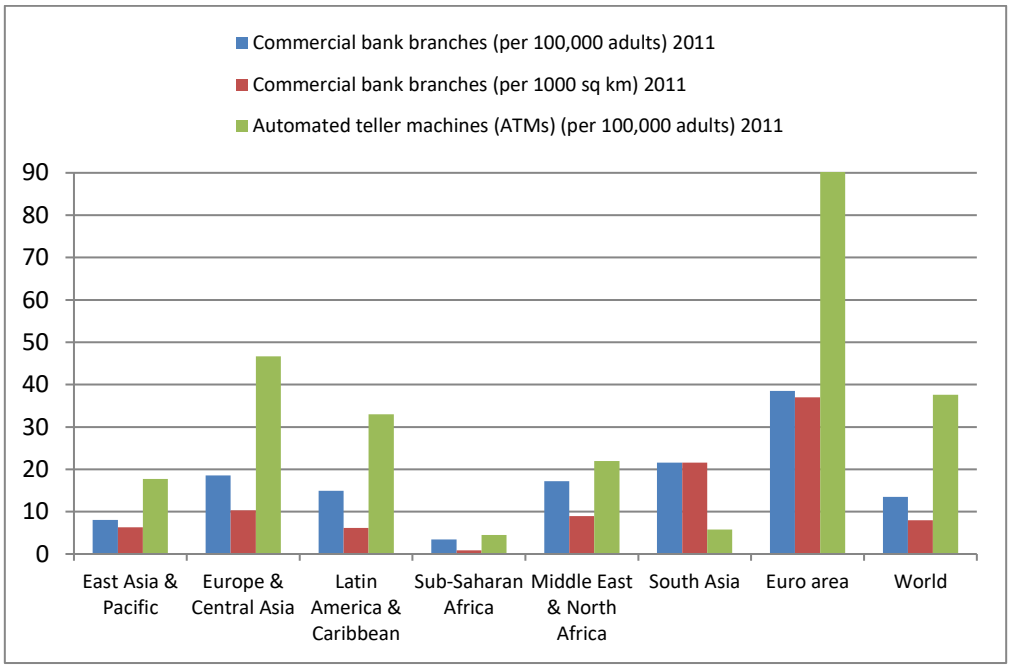
Source: Data from the GSMA State of the Industry report (2017).
Notes: The first mobile money system was launched in the Philippines in 2001, and M-Pesa in 2007.

Figure 2: Growth of active (90 day) mobile money accounts by region



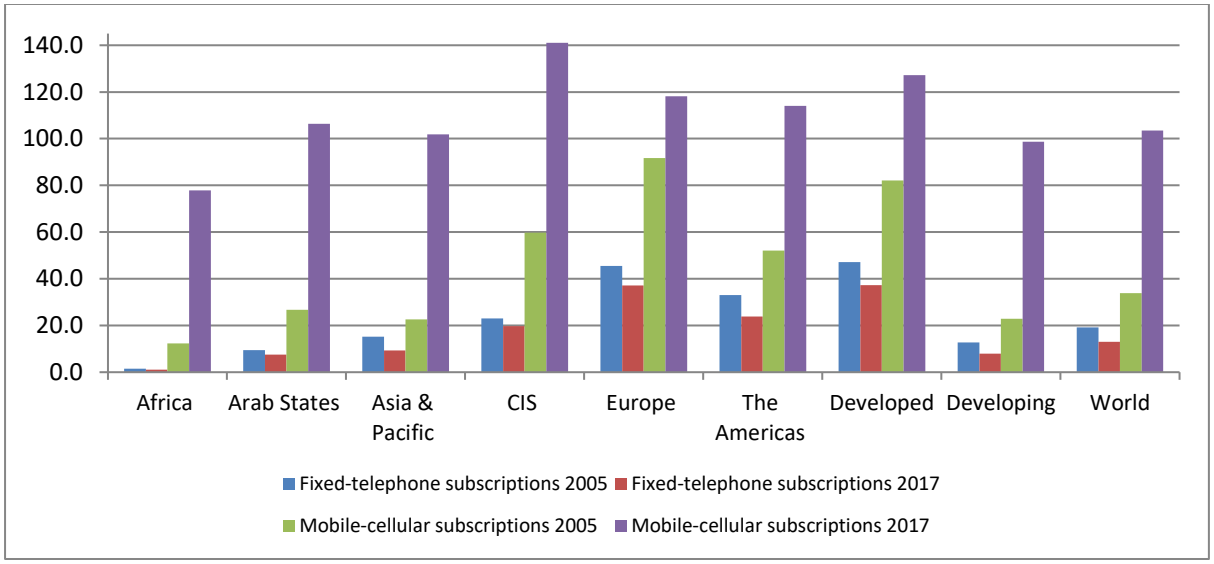
Source: Data from the GSMA State of the Industry report (2017).

Figure 3: Provision of banking infrastructure



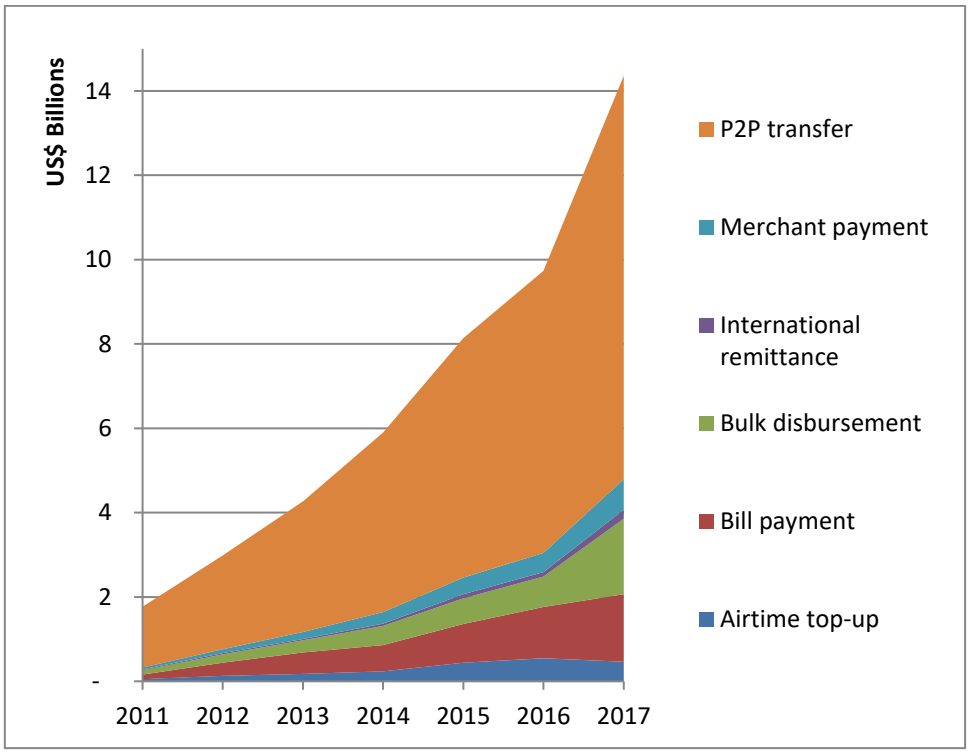
Source: Data from the G20 Financial Inclusion Indicators database, World Bank.
Notes: This shows the position in 2011 a few years after the adoption of mobile money in Kenya. The first five regions refer to "developing only".

Figure 4: Fixed telephone and mobile-cellular subscriptions: 2005 and 2017



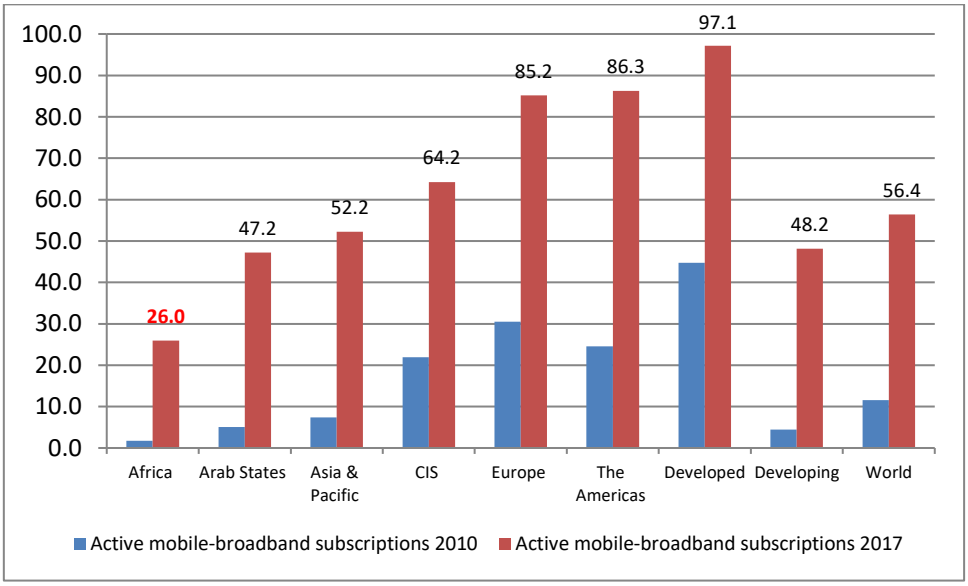
Source: Data from the ITU World Telecommunication, ICT Indicators database.
Notes: Subscriptions are per 100 inhabitants. "Mobile phone subscribers" refer to active SIM cards rather than individual subscribers.

Figure 5: Growth of a diverse payments platform



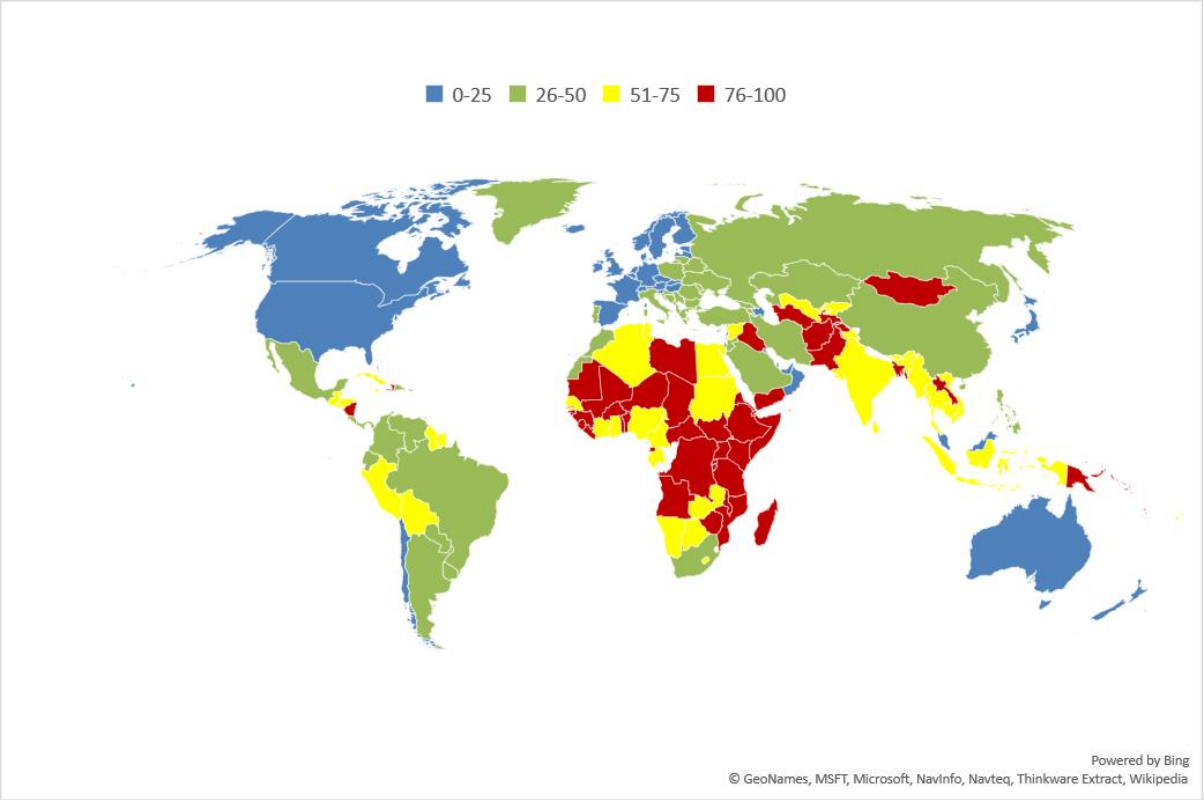
Source: Data from the GSMA State of the Industry reports (2016 and 2017).
Note: Bulk payments include salary and pension payments, and government or NGO transfers.

Figure 6: Growth of mobile broadband subscriptions, from 2010 to 2017



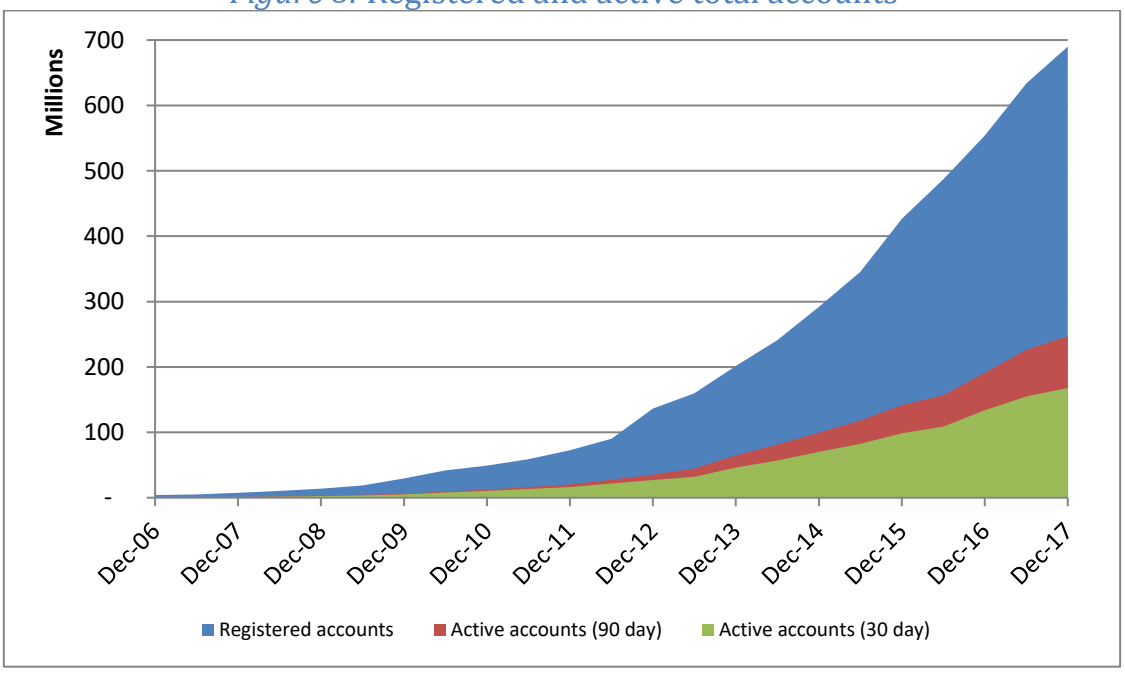
Source: Data from the ITU World Telecommunication, ICT Indicators database.
Notes: Active subscriptions per 100 inhabitants. There are data for fixed-broadband subscriptions, but uptake remains very limited in LDCs, with only one subscription per 100 inhabitants

Figure 7: The percentage of people NOT using the internet in 2016



Source: Data from the ITU World Telecommunication, ICT Indicators database.

Figure 8: Registered and active total accounts



Source: Data from the GSMA State of the Industry report (2017).
Note: This figure shows that of the 690,000 registered accounts in December 2017, only 168,000 were 30 day active (i.e. at least one transaction was performed in the preceding 30 days).